MOTOR PERFORMANCE AND RHYTHMIC PERCEPTION OF CHILDREN WITH INTELLECTUAL AND DEVELOPMENTAL DISABILITY AND DEVELOPMENTAL COORDINATION DISORDER

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Professionals who work with children presenting intellectual and developmental disability (IDD) and developmental coordination disorder (DCD) are concerned with their motor development and their rhythmic perception. The aim of this study is to investigate the correlation between a motor performance test and a music rhythmic test that measures performance of rhythmic perception in tactile, auditory, auditory-visual, auditory-visual-tactile sensory conditions. Participants were 19 children, ten with intellectual and developmental disability (IDD) and nine with developmental coordination disorder (DCD), their age ranging between 5 to 12 years. The results confirmed numerous links between motor performance scores and rhythmic perception scores. These findings are in line with previous theoretical standpoints and empirical research. However, further research is needed to determine the exact relationship between suggested motor performance factors and rhythmic perception factors.

The close relationship between physical movement and music has frequently been observed in the literature (Sutton, 1984; Michels, 2001). According to Sutton (1984, pp. 161) *physical movement and music are closely related*. Music elements, such as pitch, tempo, rhythm, melodic pattern demand physical movements (e.g., Michels, 2001). Thus, music performance is affected by motor skills.

Although systematic research with typically developing children and children with disabilities has proven the relation between music, motor and academic skills (Altenmüller, Wiesendanger, & Kesserling, 2006; Amrhein, 1993; Buday, 1995; Gilbert, 1980; Grant & LeCroy, 1986; Gruhn, 2002; Jones, 1986; Orsmond & Miller, 1995; Pellitteri, 2000; Rider, 1981; Tanner, 2001) there is a lack of research specifying the skills that are involved in and are prerequisites for rhythmic perception and motor performance.

On an international level, the acceptance that children with IDD and DCD exhibit a full range of disorders in psychomotor, sensory motor, perceptual motor and music development (Atterbury, 1983; Ayres, 1991; Jones, 1986; Missiuna, Moll, King, Law, & King, 2006) has increased the importance of understanding how measures of these areas are related. The importance of music skills and particularly of rhythmic perception in teaching sensory motor sequencing has drawn researchers' attention (e.g., Grant & LeCroy, 1986). However, in Greece research and empirical evidence into interdisciplinary assessment is lacking.

The need to better understand the complex problems that are reflected by the child's profile, especially of children with IDD and DCD, seems to be ultimately served by multidimensional solutions (Dreachslin, Hunt, Sprainer, & Snook, 1999; Polmanteer, 1999). It is clearly important to fully assess their abilities, both their limitations and strengths, in order to help children with IDD and DCD, and provide information and support to their families, teachers and therapists.

The success of such an assessment largely depends on the cooperation between various professionals who have to cope with a variety of obstacles and impediments in performing an assessment and implementing an intervention program. In order to achieve cooperation between professionals, it is important to find areas of overlap and decide what each professional will focus on.

Assessment as an essential prerequisite for organizing an educational program (a) involves the systematic observation and recording of functional skills at different developmental levels and (b) aims at defining the target skills and the behavioural strategies that should be included in the educational program of the child with special needs. A consideration of the aetiology of the disability may be conducive to the success of an educational program; however, overemphasis on aetiology may lead to an underestimation of functional aspects of the behaviours and the skills of each child.

A lot of theories in order to investigate the importance of aetiology and the important parameters regarding assessment, intervention and educational programmes are built on both brain and behavioural research (Altenmüller et al., 2006; Ayres, 1991; Missiuna et al., 2006). According to the Sensory Integration Theory, *when the activity of a sensory system becomes more organized, or various sensory systems become more integrated with one another, the nervous system functions in a more* holistic *manner* (Ayres, 2008, pp. 45). Thus, children perceive and process different *information through visual, auditory and kinaesthetic modes* (Jones, 2006, pp. 52). A multimodal approach supports interdisciplinary assessment since it focuses on the modes that a child uses in order to perform in different activities that require different processes. Researchers have investigated the modes children with special needs use for rhythm discrimination and performance (Jones, 2006; Grant & LeCroy, 1986) but they didn't attempt to match or compare preferred modes with other skills in e.g. motor skills.

While the international research community acknowledges the significance of interdisciplinary assessment, in Greece relevant research and empirical evidence is lacking. Thus, further research is needed in order for the research community to focus systematically on how children with disabilities perceive and process different kind of stimuli. The questions that arise for the researchers regarding assessment and educational implementation in Greece are: (a) Can this study support a multimodal approach? (b) How do children with IDD and DCD receive and process different kinds of stimuli? (c) How can we interpret those findings in consideration to special education research?

This pilot study aims to investigate the correlation between the scores of the short form of Lincoln-Oseretzky-Scale (LOS-KF-18) (Eggert, 1974), that evaluates the motor development/performance and a rhythmic/music test (Grant & LeCroy, 1986), that evaluates the performance of rhythmic perception in four different stimuli conditions (via tactile, auditory, auditory-visual and auditory-visual-tactile presentations). While agreeing with the international literature (Amrhein, 1993; Gilbert, 1979) that accepts that a correlation exists between motor performance and performance of rhythmic perception, the present study focuses on a differentiated multimodal interpretation of the anticipated results of the correlations among elements of motor and rhythmic development, such as pitch, tempo.

Method

Participants

Participants were 19 children (15 boys and 4 girls) with IDD (N = 10) and with DCD (N = 9). The mean age of the participants was 7.3 years ($S.D.$ = 1.6). From the participants with IDD eight children were diagnosed with ID, three with mild ID and five with moderate ID, according to Wechsler Intelligence Scale for Children Revised (WISC-R) (Wechsler, 1974) and two of them with Autism Spectrum Disorder according to DSM-IV-TR (APA, 2000). The children with DCD (N = 9) were diagnosed according to DSM-IV (APA, 1994). The diagnosis was conducted by a local Center for Diagnosis, Differential diagnosis, and Support (CDDS) that has the legislative competence according to the Greek Laws 2817/2000 and 3699/2008 to identify the special needs and disabilities of school age children. None of the subjects was diagnosed as having any sensory impairment.

According to non-parametric tests for independent samples there was no significant difference in age between boys and girls or between disability groups. In order to serve the exploratory character of the present study a convenience sample was used (Patton, 1990). Thus, a relatively small number of children who fulfilled the above-mentioned criteria were selected.

Instruments

Lincoln-Oseretzky Scale (Eggert, 1974). In order to assess the children's gross and fine motor skills a short form of the Lincoln-Oseretzky Scale (LOS-KF-18) was used. This is a test of motor development that was worked out by Eggert (1974) and it was widely implemented (e.g., Simons, 1992; Steinmacher, Pohlandt, Bode, Sander, Kron, & Franz, 2007). The LOS-KF-18 presents very good properties as far as objectivity, test-retest-reliability and validity are concerned. It provides norms for children with intellectual disability, learning disabilities and typically developed children, aged five to thirteen years. The test contains 18 items that are very similar to the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978). These items assess balance, bilateral coordination, visual-motor control, upper-limb coordination and upper-limb dexterity.

The LOS-KF-18 was selected for the present research, because: a) it offers norms for comparison, separately for three population groups, b) the materials used are simple, c) the administration time is short and d) it covers a variety of gross and fine motor skills. Of course, the LOS-KF-18 does have certain limitations, in that it is a one-dimensional test and provides a single total score. Another restriction is that norms for children with intellectual disability refer to ages of 7-14 years while there are no norms for children with developmental disabilities. For this reason, in the present study, norms were essentially not used since the aim is a correlation with other variables and not a precise diagnosis. Moreover, in this exploratory research the correlations of each item of the LOS-KF-18 with each item of the music rhythmic test were investigated. Initial performance values of each item were employed in the examination of correlations.

Music Rhythmic Test (Grant & LeCroy, 1986). The rhythmical perception was measured according to a test that evaluates the performance in rhythm pattern duplication tasks when the same information is received via tactile, auditory, auditory-visual and auditory-visual-tactile stimuli (Grant & LeCroy, 1986). This test offers no norms and was first conducted on children with mild intellectual disability. Two hand drums, 6 inches in diameter, were used during the testing procedure. The experimenter used one drum to present the rhythm patterns, and the child used the other to perform the patterns. Rhythm patterns selected for the test (see Figure1) consisted of five patterns randomly selected from the possible combinations of quarter notes and eighth notes in 2/4, 3/4 and 4/4 meters. Each rhythm pattern was presented twice within each of the four conditions for a total of 40 items.

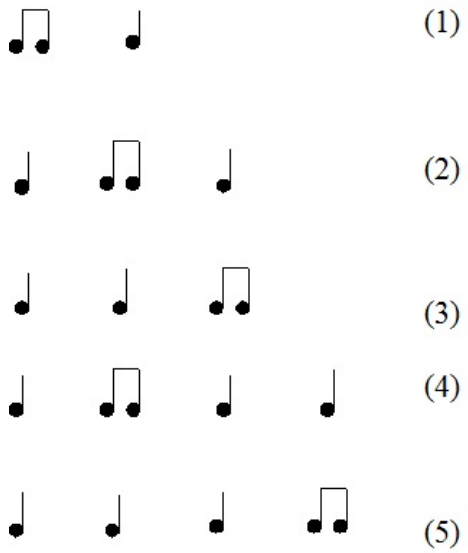

Figure 1. Rhythm Patters (Grant & Lecroy, 1986)

Test items were presented in random order (Grant & LeCroy, 1986). The tactile items were presented by tapping the rhythm patterns on the back of the subject's shoulder, out of visual range. The auditory items were presented by tapping the rhythm patterns on a hand drum behind the subject. The audio-visual items were presented by tapping the rhythm patterns on the hand drum within the subject's visual range. The audio-visual-tactile items were presented by tapping the subject's knee and speaking the rhythm on the syllable *ta*. For each item the score is 10, which means that the total score was 40. Duplication was not

requested of the participants because a pre-test to the research indicated that not all students understood the concept.

Testing Procedure

Testing was conducted individually in a familiar therapy room in a Therapy Centre in Thessaloniki (North Greece). The research took place from March until June 2009. The first step was to contact the parents and inform them about the whole process in order to get their approval for their child to participate in the research. The medical file of each child was studied and in cooperation with the psychologist of the Therapy Centre the children were chosen. None of the subjects were diagnosed as having any sensory or motor disability. First the children were assessed regarding the rhythmic performance and then the LOS-KF-18 was conducted. The time span between the two testing procedures was no longer than two months. The interdisciplinary team included a physical education teacher, who conducted the LOS-KF-18, a music teacher, who conducted the music rhythmic test, and an ergotherapist as a consultant and supervisor of the procedure.

Data Analysis

The data analysis was carried out through the statistical package SPSS (SPSS, Inc., 2003). Basic descriptive statistics were initially calculated. Then, the relations between the variables were evaluated via the calculation of *Spearman's rho* (R). This coefficient was used because the sample is small and because the variables present different scales (Bortz, 1993, pp. 197, 214). Even if the correlations with a small error rate (< 5%) are considered as significant, estimates with less than 10% rate of error can have a certain value, because of the small research sample (Bortz, 1993, p. 114).

Results

The children's raw scores in the LOS-KF-18 ranged from 0 to 10 points, whereas the highest possible raw score was 18. The mean performance of children was 3.3 points (*S.D.* = 3.2). With regard to the norms of children with typical development this score corresponds to a *t*-score of 32.6 (*S.D.* = 10.4), when the mean of the typically developed children is considered to be 50. Table 1 attributes the descriptive statistics of the research variables.

Table 1. Descriptive statistics of the research variables

	Mean	Standard Deviation
Age (in years)	7.3	1.6
LOS-KF-18 (raw score)	3.3	3.2
LOS-KF-18 (*t*-score)[1]	32.6	10.4
Tactile item	3.3	3.3
Auditory item	3.4	3.0
Audio visual item	4.0	3.3
Audio-visual-tactile item	4.2	2.9
Rhythmic perception total score	14.8	11.6

[1] Norms for typically developed children

With reference to linear correlations, the age of children showed moderate connections to LOS-KF-18 total raw score ($R = .40$, $p < .10$) and to the tactile item ($R = .44$, $p < .10$). It appears that the raw score of the LOS-KF-18 strongly correlated with all values of the four items of the music rhythmic test (each time: $R > .75$, $p < .01$). All the correlations among the four items of the music rhythmic test were statistically significant (each time: $R > .73$, $p < .01$).

Table 2 lists all the correlations that were found to be statistically significant. Overall, items 2, 8 and 11 of the LOS-KF-18 showed strong correlations with all items of the music rhythmic test. Item 2 involves foot and finger synchronized tapping and serves as an indicator of gross motor bilateral coordination. Items 8 and 11 require (bimanual) fine motor coordination under time pressure and depict manual dexterity.

Table 2 Correlations between LOS-KF-18 items and Rhythmic Perception items

	LOS-KF-18 items	Tactile item	Auditory item	Audio-visual item	Audio-visual-tactile item
01	Touching nose with index fingers	.67**	.36	.46*	.37
02	Foot-Finger synchronized tapping	.48*	.47*	.45†	.52*
03	Walking backwards heel to toe	.29	.29	.46*	.24
04	Jumping over a 40 cm high rope	.48*	.58**	.66**	.23
05	Standing on preferred leg	.38	.43†	.47*	.29
08	Placing matches in boxes	.55*	.48*	.46*	.65**
09	Jumping up and touching heels	.39	.45†	.50*	.38
11	Transferring pennies and matches	.71**	.62**	.52*	.73**
12	Drawing a line through a curved path	.55*	.31	.40†	.55*
14	Cutting out a circle with scissors	.46*	.25	.26	.45†

** $p < .01$; * $p < .05$; † $p < .10$

Furthermore, item 1 of the LOS-KF-18 (touching nose with index fingers), which demands good levels of proprioception, presented a very strong connection to the tactile item of the music rhythmic test. Item 3 (walking backwards heel to toe) was significantly linked only to the audio-visual item of the music rhythmic test. The two strongest correlations of the items 4 (jumping over a rope), 5 (standing on preferred leg) and 9 (jumping up and touching heels) refer to the auditory and audio-visual items of the music rhythmic test. Items 3, 4, 5 and 9 principally describe the balance skill. Finally, items 12 (drawing a line) and 14 (cutting out a circle), which represent fine motor precision, demonstrated significant correlations with the tactile and the audio-visual-tactile items of the music rhythmic test.

Discussion

There has been a lot of discussion about the development of music motor skills (e.g., Gilbert, 1980). However, the relation between motor and musical skills in Special Education has not yet been researched extensively. The correlation of the scores of different assessment instruments is a prerequisite within an interdisciplinary assessment framework. The fact that some items have shown correlation may be due to the relationship between adequate function in rhythmic processing and motor performance and planning. An interesting finding was the positive correlation of the auditory and audiovisual items with gross motor movement, balance, and coordination. This correlation may be due to the fact that adequate auditory and visual function is necessary in order to receive a high score in such a complex and bilateral test as that in the LOS-KF-18. At the same time vestibular sense is connected with the inner ear and is responsible for the gravity, head movement and balance (Ayres, 2008).

The results of our study indicate a powerful interdependence between performance of rhythmic perception and motor performance, which is consistent with previous approaches and findings (e.g., Gilbert, 1979; Orsmond & Miller, 1995; Gruhn, 2002). Apart from the total score of motor performance, several motor performance items display significant links to rhythmic perception. Specifically, balance is directly correlated with the auditory ability, whereas coordination of fine and rhythmic movements is correlated with the reproduction of rhythmic patterns. Furthermore, items 4 *Jumping over a rope 40 cm high* and 5 *Standing on preferred leg* of LOS-KF-18 were correlated with the auditory items while item 4 is also correlated with the visual-auditory items, as this exercise is based on visual perception as well as on the relation of the auditory item with balance. According to the theory of Sensory Integration, the tactile system is responsible for visual perception and motor planning (Dunn, 1999). This may be the reason why there has been a recorded correlation between items on motor-visual coordination in LOS-KF-18 and items on the tactile items in the music rhythmic test. Similarly, items of fine motor skills are significantly correlated only with items involving tactile skills. As in the research of Grant and LeCroy (1986) we can assume that the auditory – visual mode is used more frequently in intervention and educational programs. On the other hand there is a possibility that children may have not developed much reliance on tactile conditions.

Conclusion

Conforming to the Sensory Integration theory (Ayres, 1991; Dunn, 1999) this exploratory study shows that a multimodal approach could be supported. The research of Grant and LeCroy (1986) gives interesting results regarding the performance of the participants but those results could have been further interpreted if more information was given about the ways the participants perceive different stimuli. For example the research of Grant and LeCroy showed that the tactile input was the poorest condition for all participants a data that could be connected and further investigated according to Sensory Integration (Ayres, 2008) since a relationship exists between adequate function in tactile processing and motor planning and performance.

The researchers took into consideration two facts: (a) rhythm is the most prominent component of music linked with the individual's motor behaviour, indicating the responsiveness of the sensorimotor system to auditory stimuli (e.g., Styns, van Noorden, Moelants, & Leman, 2007) and (b) perception refers to all sensory experiences that are created from the stimulation of sensory organs, such as the eye and the ear (e.g., Ayres, 2008). Nevertheless, the viewpoint taken in this study must be further investigated, possibly through the Sensory Integration and Praxis Test (SIPT) of children, through which more data can be collected concerning the ways in which children process sensory stimuli. The ability of movement planning, processing of sensory stimuli, and organization of movement is a neurological function (e.g., Ayres, 2008). Regarding the second research question of this study, children with IDD and DCD receive, process, and respond to different kinds of stimuli according to the senses aroused. Their performance is influenced by the different kinds of conditions so that the motor performance and rhythmic perception are correlated to different senses. That enforces the theory of multisensory approach in assessing and educational implementation (Ayres, 2008; Michels, 2001; Polmanteer, 1999)

Conclusively, this research indicates that in the future interdisciplinary assessment and correlations of scores of different assessment instruments will be acknowledged as being highly important for the interpretation of children's functioning. The fact that half of LOS-KF-18 items (9 out of 18) are correlated with the four items of the music rhythmic test reflects the need for further systematic research. Future research must employ larger samples and include more diversified quantitative measurements accompanied by qualitative observations. There were some general constraints on this study. As it happens with most pilot studies, the findings act as suggestions for further examination. This is mainly due to the small sample and to the sampling method, which render the generalization of conclusions impossible. Similarly, correlation analyses that were used only show interdependencies but not direction of causality. Nevertheless, such attempts open up orientations towards new fields of research or new population samples.

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